TURBOT CULTURE: PROBLEMS AND PROSPECTS
Lavens P. and R.A.M. Remmerswaal (Eds.)
European Aquaculture Society, Special Publication No.22, Gent, Belgium, 1994

RESEARCH ACTIVITIES ON TURBOT INDUSTRIAL PROCEDURES IN SPAIN

J. Iglesias.

Instituto Español de Oceanografía. Centro Oceanográfico de Vigo, Apdo.1552, 362880 Vigo (Spain)

1 Abstract

This technical report deals with the evolution during the last decade of the research activities of the governmental institutions working on the development of turbot (*Scophthalmus maximus* L.) culture. The Instituto Español de Oceanografía (Santander and Vigo), the C.S.I.C. (Vigo and Castellón), the Xunta de Galicia (Villajuán and Couso) and The University of Santiago are the institutions analyzed. A general review of the different projects on turbot farming is given, including those with grants from the institutions and from the C.I.C.Y.T. (Comite Interministerial de Ciencia y Tecnología), C.D.T.I. (Centro de Desarrollo Tecnologico e Industrial) and the EC (European Community). Finally, an analysis is given of the present situation and bottlenecks to development are highlighted, leading to priorities for future research.

2 Introduction

During the last ten years, the industrial applications resulting from turbot culture research in Spain have increased enormously, especially in Galicia, having an initial production in 1985 of 40 tonnes annually this will have reached an annual production of 2,000 tonnes by the end of 1992. This increase in industrial production agrees with the estimations of the multi-annual program of the Secretaria de Pesca Maritima, which projected a production of 50 tonnes in 1987 and for 1991 1,000 tonnes annually. The projection estimated for 1995 is 4,700 tonnes, but the current cultivation of the species, as well as current market conditions, lead to doubts about these estimates. This communication tries to analyze the current situation in Spain and the future prospects for the cultivation of this species.

During the 1980's in Spain, several initiatives took place for the development of aquaculture on an industrial scale (Directives of the Ministry of Agriculture, Fisheries and Food, and the Instituto Español de Oceanografía). As a result of these initiatives, the I.E.O. in Santander and Vigo officially pioneered turbot cultivation in Spain. It is now widely recognized that the first results of fattening turbot fry in Spain (Iglesias *et al.*., 1985 and 1987) have played an important part in the first steps of the industrial development of turbot cultivation in Galicia. Beginning with fry of 5 to 9 g, mean

weights after 17 months of 1,100 to 1,900 g were achieved. The rapid growth of turbot in Galicia has provoked a great interest in the industrial cultivation of this species. Several studies concerning the fattening of fry in tanks have been published by staff of the I.E.O. (Iglesias *et al.*, 1987; Fernandez-Pato 1990a; Sanchez *et al.*, 1990a) and have been followed subsequently by studies of fry fattening in floating cages (Sanchez, 1990b), oxygen consumption (Sanchez, 1993), and the use of dry feeds during the fattening phase (Cal *et al.*, 1993).

Twentytwo companies have joined to form an organization called AROGA (Asociación de Productores de Rodaballo de Galicia) in the beginning of the 1980's. This has resulted in the consolidation of the industrial applications of fry fattening by Insuiña in Galicia as well as the start of turbot research by teams of other official research centers (Planta Experimental de Villajuán-Xunta de Galicia in 1984; Instituto de Investigaciones Mariñas of the C.S.I.C. in Vigo in 1987; Centro de Experimentación en Acuicultura de Couso-Xunta de Galicia in 1991; and Instituto de Acuicultura de Torre de la Sal in Castellón, from the C.S.I.C. in 1992). The President of AROGA declared in late 1992 during the J.A.C.U.M.A.R. meeting in Bilbao, that despite the important technical advances in the cultivation of turbot, *i.e.* fry production, as well as in ongrowing, the economical situation remains difficult due to reduction of the prices ex-farm by 50%, *i.e.* from 1,800 to 900 Pts./kg. Since support for these investigations funded by the E.C., C.D.T.I., and C.I.C.Y.T. has been considerably reduced in recent years, it is necessary to concentrate attention and coordination, to define the long term aims and to promote coordinated projects between the research centers and the industrial sector.

3 Present situation: Research Projects

The following list of official research centers and their projects in Spain (including 1992) is listed below as a background to the present research situation:

3.1 Instituto Español de Oceanografía

Centro de Vigo

-Methods to evaluate the nutritional status of larval turbot (1990-1993). FAR project with DIFTA (Denmark), University of Ghent (Belgium), University of Heidelberg (Germany) and Fish Biology Center (Denmark). P.I.: J. Iglesias and M. Olmedo.
-Research on turbot feeding with dry high-yield diets (1992-1993). CDTI Project in collaboration with the EWOS company. Sectorial project of I.E.O. P.I.: R.M. Cal.
-Use of natural zooplankton as a larval turbot diet. I.E.O. project P.I.: F.J. Sanchez.
-Tagging and experimental release of turbot fry (1992-1993). Sectorial project of I.E.O. recently adopted by AAIR-EC. P.I.: J. Iglesias.

Centro de Santander

-Effect of A.G.E., vitamin E and L-carnitine on turbot cultures. I.E.O. Project. P.I.: Carlos Fernández-Pato.

-Effect of tocoferol, vitamin C and L-carnitine on larval culture of turbot and red sea bream. I.E.O. Project. P.I.: Carlos Fernández-Pato.

-Conservation of frozen sperm and embryos from cultured marine fish. I.E.O. Project. P.I.: Olvido Chereguini.

-Study of the influence of different enrichment factors on larval turbot development. I.E.O. Project. P.I.: Inés García de la Banda.

3.2 Consejo Superior de Investigaciones Científicas (C.S.I.C.)

Instituto de Investigaciones Marinas, Vigo.

-Effect of food protein content on growth, survival and metabolic rates in turbot larvae. F.A.R.-E.C. Project in cooperation with Institut für Meereskunde (Germany). The Biological Laboratory (Denmark), and Butt Company (Germany). P.I.: Roberto Munilla.

-Trophic behaviour and energetic physiology of turbot larvae in different culture conditions. C.I.C.Y.T. Project. P.I.: Miguel Planas.

Instituto de Acuicultura de Torre de la Sal. Castellón.

-Control of maturation and spawning in turbot brood stock (1991-1994). Project C.D.T.I. with the Tinamenor S.A. company.

3.3 Xunta de Galicia

Centro de Investigaciones Mariñas (Villaxoán)

-Optimization of yields of eggs and viable hatched larvae in industrial scale turbot hatcheries (1990-1992). Project C.D.T.I. in collaboration with Insuiña. P.I.: Ricardo Arnáiz.

-Larval quality and survival at hatching and metamorphosis, and biochemical control of larval histology (1991-1992). Xunta Project. P.I.: Ricardo Arnaiz.

-To improve and establish fry production techniques for turbot in hatcheries (1991-1992). Technology Transfer Technology of Xunta de Galicia and Insuiña S.A.

Centro de Experimentacion en Acuicultura (Couso)

-Effect of photoperiod and feeding on turbot reproduction (1990-1992). Self-financed. P.I.: Alicia Estévez.

-Culture and enrichment of live prey (1991-1992). Self financed P.I.: Aurelio Ortega

-Optimization of rotifer and copepod culture. (1993) Selffinanced project in collaboration with I.I.M. Vigo. P.I. Fátima Linares.

3.4 Santiago University

Although I have not been able to obtain precise information from the various faculties, during recent years the following R&D turbot projects were started:
-Bacterial and viral pathology of turbot, seabass, and salmon in culture systems. Biology Faculty. P.I.: J.L. Barja. 1984.
-Characterization of a new turbot virus. Biology Faculty. P.I.: J.L. Barja. 1989.
-Characterization of karyotypes and allozymes of cultivated and wild turbot fry populations. Veterinary Faculty (Lugo). P.I.: L. Sánchez. 1991.
-Pathology of turbot. Biology Faculty. C.D.T.I. Project in collaboration with the company Neptuno Atlantico S.A.

3.5 Turbot projects supported by CICYT, CDTI and EC

Comite Interministerial de Ciencia y Technologia (CICYT)
C.I.C.Y.T. data banks have been reviewed to study the development of financed R&D projects on turbot for the period 1982-1986, and subsequently within C.I.C.Y.T. in its National Aquaculture Program. These are presented in Table I. Three of these Projects were related to turbot pathology, one included the different phases of culture of the species, and the other larval physiology. Overall, the participation of C.I.C.Y.T. in turbot projects was low compared to projects on other marine species such as seabass on seabream.

Centro de Desarollo Technológico e Industrial (CDTI)
Among the public notices of C.I.C.Y.T., there is a budgetary endowment which corresponds to the National Plan to finance coordinated research projects by companies in collaboration with public institutes. The projects shown in Table II, related to turbot, were supported by PLANICYT from 1988 to 1992.

E.C.
Spanish participation in the F.A.R. Program of the E.C. was generally low, with only 16 projects, of which two concerned turbot culture (Table III). During the recent A.A.I.R. consultations of the E.C., Spanish participation has been even less, and approved projects were limited almost exclusively to the pathology of other species, and to the marking of turbot fry for restocking projects. This, and the fact that future directions within the E.C. and the National Plan include aquaculture within the scope of agriculture and the agro-industry including the fisheries, makes it clear that the financing of future projects on turbot culture will become even more difficult if not impossible in the future.

Table I. Turbot projects supported by CICYT.

TITLE	CENTRE	P.I.	YEAR	GRANT (Mill. Pts.)
Research on the different phases of turbot culture in Galicia.	I.E.O -Vigo	J. Iglesias	1982	10.5
Bacterial and viral pathology of turbot, sea bass and salmon in culture systems.	Univ.Santiago Fac. Biology	J.L Barja	1984	31
Characterization of a new turbot virus	Univ.Santiago Fac. Biology	J.L. Barja	1989	11
Characterization of caryotypes and allozymes of cultured end wild turbot fry	Univ.Santiago Fac.Veterinaria. Lugo	L. Sanchez	1991	13.9
Feeding behaviour and physiology of turbot larvae in culture.	C.S.I.C.- I.I.M. Vigo	M. Planas	1992	11

Table II. Turbot projects supported by CDTI.

TITLE	COMPANY	YEAR	GRANT
Research on larval turbot nutrition.	Cultipec S.A.	1988	26.8
Optimising yield of turbot eggs and larvae.	Insuiña S.A.	1989	17.2
Research on turbot infections.	Tinamenor S.A.	1989	18.4
Effect of different kinds of feed on turbot health.	Acuidoro S.L.	1991	11.0
Research on and characterization of dry feeds for turbot, seabass and gilthead seabream.	EWOS S.A.	1991	19.0
Control of maturation and spawning of turbot brood stock.	Tinamenor S.A.	1991	31.5
Study of turbot pathology.	Neptuno Atlantico S.A.	1992	12.1

Note: The average assistance provided is equivalent to 40-50% of the total project budget.

Table III. Turbot projects supported by the EC.

TITLE	INSTITUTE	YEARS	ECUS
Methods for the evaluation of the nutritional status of fish larvae. Project AQ.1.60	DIFTA (Denmark) Univ. Ghent (Belgium) IEO-Vigo (Spain) Univ. Heidelberg (Germany) Fish Biology Center (Denmark)	1990-1993	242,262
Effects of foods protein content on growth, survival and metabolic rates in young turbot larvae. Project AQ.3.629	Univ. Kiel (Germany) Univ. Keebenharn CSIC.IIM. VIGO		300,000

4 Plans for future research lines

Aquaculture in general and turbot culture in particular has been financed to a significant extent since 1983. As a result of the approval of the Aquaculture R&D plan for both research and industrial development, the disappearance of the National Plan and the specific program on Marine Resources and Aquaculture (aquaculture is now included in the Program on Agrarian Sciences), and the integration of the F.A.R. Program with A.A.I.R. in the E.C., serious problems are created for the future financial support of turbot projects.

The ample economical support directed to personnel training, infrastructure, projects and industrial development allowed research teams in public institutes to be redirected and strengthened. Also, C.D.T.I. projects resulted in an increase of interactions between these teams and the private sector.

Today the combined force of both sectors represented at this Congress is necessary to verify the present state of turbot culture and the future lines of research necessary for the culture of this species. The final document must serve as a basis for future national and international funding when these research directions are taken up by competent groups. The alternative will be to accept that everything has already been done with turbot, and to advise that no further funding of research on this species should occur.

For that, one would need to explain whether the causes are due to the current market situation (sale prices, recovery of investments to companies, profitability, *etc.*), or that from the technical point of view all stages of cultivation are already well controlled. This alternative would have to assume that questions such as the following have already been resolved:

Reproduction
-Is it possible to control the spawning sequence of the broodstock?;
-What is the appropriate diet to obtain good spawnings of broodstock?;
-Is it possible to control spawning by photoperiod or by hormonal induction?;

Larviculture
-What percentage of larval survival can be achieved on an industrial scale?;
-What are the nutritional needs of larvae?;
-Is the problem of albinism solved in intensive culture?;

Fattening
-Is a suitable feed for fattening available?;
-What are the conversion indices with dry feed and moist feed?;
-Can turbot diseases be controlled at an industrial level?;
-Is the extensive system better than the intensive one? Is it applicable in Spain?;

I think that these and many other questions must be answered positively before research on a species is stopped. Therefore it is evident that my proposal is to define the priorities of future lines of investigation which emerge jointly from the industrial sector and researchers in public institutes.

At the occasion of the Aquaculture Working Group during the R&D Marine Science and Technology Meeting, held in Alicante (June 1992), research topics were proposed by a group of ten experts in aquaculture from various official research centers in this country:

-Physiology of reproduction; Spawning quality; Control of sex and puberty; Cold conservation of gametes; Genetic improvement; Larval feeding and metabolism; Pigmentation; Juvenile and adult feeding; Techniques to improve growth; Diagnosis and control of viral and bacterial diseases and parasites and Epidemiology.

On the other hand, APROMAR (Managers Association for Cultivated Marine Products) has proposed on various occasions to maintain the general lines of the National Program of Marine Resources and Aquaculture, and emphasized the need to continue applied research on the following aspects:

-Methods to control sexual maturation;
-Feeding requirements of broodstock, larvae and juveniles;
-Evaluation of commercial diets;
-Creation of public laboratories for pathology and genetics and establishment of genetic banks;
-Farm management: emergency systems, stocking densities, oxygen consumption, water flow rates, *etc.*;
-Engineering aspects, economical analysis and market.

As complementary lines to turbot culture, other projects could be established on the viability in culture of other autochthonous species, the introduction of exotic species, restocking experiments, or interactions between the environment and culture activities.

5 Sources

Cal R.M., M. Olmedo and B. Alvarez-Blazquez. 1993. Investigación y caracterización de la alimentación del rodaballo (*Scophthalmus maximus*, L.) con dietas de alto rendimiento. Congreso Mundial de Acuicultura. Torremolinos, España.

Fernandez-Pato C., I. Martinéz Tapia and O. Chereguini. 1990. Larval rearing of turbot (*Scophthalmus maximus*, L.): Effect of density. ICES C.M./F:24.

Iglesias J., M. Olmedo, J.J. Otero, J.B. Peleteiro and M.R. Solórzano. 1987. Growth, under laboratory conditions, of turbot *Scophthalmus maximus*, L. from the Ría de Vigo (NW Spain). Mar. Biol. 96:11-17.

Sanchez F.J., 1990a. Estudio comparativo del crecimiento del rodaballo (*Scophthalmus maximus*, L.) en tanques y en jaulas flotantes. Actas del III Congreso Nacional de Acuicultura. p.209-214.

Sanchez F.J., J.B. Peleteiro, R. Forés, M. Olmedo and J. Iglesias. 1990b. Crecimiento del rodaballo (*Scophthalmus maximus*, L.) en condiciones experimentales de cultivo. Bol. Inst. Esp. Oceanogr. 6(1):127-132.

Sanchez F.J., R.M. Cal and C. Guisande. 1993. Consumo de oxigéno en juveniles de rodaballo (*Scophthalmus maximus*, L.) entre 15 y 22 °C, bajo condiciones experimentales. Congreso mundial de Acuicultura 1993. Torremolinos, España.